JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 109, D07203, doi:10.1029/2003JD004030, 2004

Combined lidar-radar remote sensing: Initial results from CRYSTAL-FACE

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Received 31 July 2003; revised 19 December 2003; accepted 24 February 2004; published 3 April 2004.

[1] In the near future, NASA plans to fly satellites carrying a two-wavelength polarization lidar and a 94-GHz cloud profiling radar in formation to provide complete global profiling of cloud and aerosol properties. The Cirrus Regional Study of Tropical Anvils and Cirrus Layers-Florida Area Cirrus Experiment (CRYSTAL-FACE) field campaign, conducted during July 2002, provided the first high-altitude collocated measurements from lidar and cloud profiling radar to simulate these spaceborne sensors. The lidar and radar provide complementary measurements with varying degrees of vertical measurement overlap within cloud layers. This paper presents initial results of the combined airborne lidar-radar measurements during CRSYTAL-FACE. A comparison of instrument sensitivity is presented within the context of particular CRYSTAL-FACE observations. It was determined that optically thin cirrus clouds are frequently missed by the radar but are easily profiled with the lidar. In contrast, optically thick clouds and convective cores quickly extinguish the lidar signal but are easily probed with the radar. Results are presented to quantify the portion of atmospheric features sensed independently by each instrument and the portion sensed simultaneously by the two instruments. To capture some element of varying atmospheric characteristics, two cases are analyzed, one with convective systems and one having synoptic cirrus and considerable clear air. The two cases show quite different results, primarily due to differences in cloud microphysics. *INDEX TERMS:* 0320 Atmospheric Composition and Structure: Cloud physics and chemistry; 0394 Atmospheric Composition and Structure: Instruments and techniques; 3360 Meteorology and Atmospheric Dynamics: Remote sensing; 3394 Meteorology and Atmospheric Dynamics: Instruments and techniques; *KEYWORDS:* lidar, radar, remote sensing, cirrus anvil

Citation: McGill, M. J., L. Li, W. D. Hart, G. M. Heymsfield, D. L. Hlavka, P. E. Racette, L. Tian, M. A. Vaughan, and D. M. Winker (2004), Combined lidar-radar remote sensing: Initial results from CRYSTAL-FACE, *J. Geophys. Res.*, *109*, D07203, doi:10.1029/2003JD004030.

1. Introduction

[2] When complete, NASA's "A-train" constellation will consist of a group of five remote sensing satellites flying in formation. The instruments aboard these satellites will provide a wealth of cotemporal and collocated data products whose synergies should provide a greatly enhanced understanding of Earth's atmosphere. The A-train takes its name from the Aqua satellite [*Parkinson*, 2003], which leads the string of satellites. Following Aqua are, in order, the CloudSat [*Stephens et al.*, 2002], CALIPSO [*Winker et al.*, 2002], PARASOL [*Deschamps et al.*, 1994], and Aura [*Schoeberl et al.*, 2001] satellites. These satellites will fly in a 705-km sun-synchronous orbit with an equatorial crossing time of 1:30 pm. This satellite formation is designed to acquire complementary data products to provide improved global remote sensing of the atmosphere.

[3] The Cirrus Regional Study of Tropical Anvils and Cirrus Layers-Florida Area Cirrus Experiment (CRYSTAL-FACE) field campaign during July 2002 [*Jensen et al.*, 2004] deployed a comprehensive suite of instruments on six aircraft and at two ground sites to study tropical cirrus cloud properties and formation processes. Sensors onboard one of the aircraft, the NASA ER-2, provided high-altitude downlooking measurements from instruments that can be considered close proxies for A-train instruments. The new Cloud Radar System (CRS) [*Li et al.*, 2003; *Racette et al.*, 2003] is a 94 GHz pulsed polarimetric Doppler radar and provides measurements similar to those of the CloudSat cloud profiling radar (although CloudSat will not have Doppler capability). The Cloud Physics Lidar (CPL) [*McGill et al.*, 2002, 2003] provides measurements similar to the polarization-sensitive lidar on CALIPSO, which operates at 532 nm and 1064 nm. Detailed instrument

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